UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555

April 21, 1993

NRC INFORMATION NOTICE 93-32: NONCONSERVATIVE INPUTS FOR BORON DILUTION EVENT ANALYSIS

Addressees

All holders of operating licenses or construction permits for pressurized water reactors (PWRs).

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to inform addressees that nonconservative assumptions have been identified in the analysis of licensing basis boron dilution events. It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice are not NRC requirements; therefore, no specific action or written response is required.

Background

The licensees for several Westinghouse-designed plants have used a boron dilution mitigation system (mitigation system) to detect and mitigate a boron dilution event in Modes 3 (hot standby), 4 (hot shutdown), and 5 (cold shutdown). The mitigation system is designed to terminate automatically an inadvertent boron dilution event occurring with the plant in these operating modes before the reactor coolant system is diluted sufficiently to result in a total loss of shutdown margin. A boron dilution event is detected by this system by monitoring the signals of the source range monitors to determine if the neutron flux has increased by a specified multiplication factor over a prescribed time period. When a dilution event is detected, the mitigation system isolates known dilution paths to the reactor coolant system and realigns the reactor makeup water system to the refueling water storage tank to initiate a re-boration.

NRC Standard Review Plan Section 15.4.6, "Chemical and Volume Control System Malfunction That Results in a Decrease in Boron Concentration in the Reactor Coolant (PWR)," specifies acceptance criteria for an unplanned boron (moderator) dilution. These acceptance criteria specify that a dilution event be terminated before total shutdown margin is lost. If operator action is required during Modes 3, 4, and 5, these criteria specify at least 15 minutes notice be provided to operators from the time at which an alarm announces an unplanned dilution to the time at which shutdown margin would be eliminated (criticality).

In NRC Generic Letter 85-05, "Inadvertent Boron Dilution Events," the staff concluded that the consequences of boron dilution events would probably not jeopardize the health and safety of the public and would not warrant backfitting requirements. However, the generic letter urged each licensee to verify that its plants have adequate protection against boron dilution events.

Description of Circumstances

In late 1991, while performing a quality assurance surveillance of Westinghouse supporting calculations for the Comanche Peak Steam Electric Station, the Texas Utilities Electric Company (the licensee) found that it could not justify using a generic curve for the relationship between the inverse count rate ratio and the reactor coolant system boron concentration, as was used in the Westinghouse boron dilution event analysis. This curve and a source range flux multiplication setpoint of 2.0 (flux-doubling) were the bases for detecting and mitigating an inadvertent boron dilution event. After further reviewing this concern, in February 1992 the licensee determined that the generic curve might not be bounding and that the analysis did not include instrument uncertainties. These deficiencies may cause Comanche Peak to be outside the licensing basis in the boron dilution event analysis which shows that the boron dilution mitigation system response will prevent a return to criticality. The licensee declared the mitigation system inoperable. While the licensee is working on the long-term solution to correct the problem, it put in place the following interim actions:

1) Within 4 hours of entry into Modes 3, 4, or 5 from Modes 1, 2, or 6 (and once per every 14 days thereafter while in Modes 3, 4, or 5), the licensee will verify (unless startup is in progress) that those valves that could contribute to the boron dilution event are closed and secured in position; or

2) Within 4 hours of entering Mode 5, the licensee will ensure that only one reactor makeup water pump (dilution source) is aligned to the supply header. Following entry into Mode 3, 4, or 5 from Modes 1, 2, or 6, each crew of the control room staff will receive a briefing to discuss the type of reactivity changes that could occur during a boron dilution event, the indications of a boron dilution event, and the actions required to stop a dilution; commence immediate boration and establish the required shutdown margin. For extended shutdowns, this briefing will be repeated for each crew prior to resumption of control room duties following an off duty period which exceeds 7 days. During time periods when this option is used, the source range will be monitored for indication of unexplained increasing counts and inadvertent boron dilution every 15 minutes.

Discussion

The inverse count rate ratio used in the Comanche Peak analysis of the boron dilution event is based on the generic curve supplied by Westinghouse. The

curve is used to predict the time at which a source range flux-doubling signal would occur as criticality is approached during a boron dilution event. Using actual Comanche Peak Unit 1 inverse count rate ratio data, the licensee determined that the flux-doubling signal and alarm detected by the mitigation system may not meet the acceptance criteria for the boron dilution event since an appreciable amount of dilution would already have occurred before the signal was generated.

The licensee also found that the flux multiplication setpoint of 2.0 does not include the instrument uncertainties that should be applied to determine the flux multiplication setpoint. These uncertainties include the statistical variation of neutron flux, the variations in the linearity of the log level amplifier as a function of counts per second, and uncertainties in numerous amplifiers and the multiplexer. Thus, an actual flux signal could exceed the flux-doubling setpoint used to analyze the boron dilution event. This condition could result in a loss of shutdown margin before the mitigation system terminates an inadvertent boron dilution event. (This problem may be applicable not only to plants that rely on an automatic mitigation system, but also to those that rely on a flux-doubling signal to generate an alarm for operator intervention.) Alternatively, setting the setpoint too conservatively could unnecessarily allow the mitigation system to be activated and the reactor coolant system to be borated. This sequence of events would have detrimental effects on operation.

On March 23, 1992, the staff met at NRC Headquarters with the licensee and Westinghouse to discuss issues discussed above. The licensee informed the staff that it had investigated various alternatives and found none readily available to restore the operability of the mitigation system but would continue to evaluate this problem with Westinghouse. Later, on December 15, 1992, the staff met with Westinghouse and licensees of Westinghouse-designed plants which use the mitigation system. It was concluded that the mitigation system was unreliable because of the large uncertainties associated with the indication of a true flux doubling by the nuclear instruments. Therefore, this problem may be common to all PWRs that rely on a flux-doubling signal to mitigate a boron dilution event before criticality can occur.

This information notice requires no specific action or written response. If you have any questions about the information in this notice, please contact the technical contact listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

Brian K. Grimes, Director
Division of Operating Reactor Support
Office of Nuclear Reactor Regulation

Technical contact: Larry Kopp, NRR
(301) 504-2879

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LIST OF RECENTLY ISSUED
NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
93-31	Training of Nurses Responsible for the Care of Patients with Brachytherapy Implants	04/13/93	All U.S. Nuclear Regulatory Commission medical licensees.
93-30	NRC Requirements for Evaluation of Wipe Test Results; Calibration of Count Rate Survey Instruments	04/12/93	All U.S. Nuclear Regulatory Commission medical licensees.
93-29	Problems with the Use of Unshielded Test Leads in Reactor Protection System Circuitry	04/12/93	All holders of OLs or CPs for nuclear power reactors.
93-28	Failure to Consider Loss of DC Bus in the Emergency Core Cooling System Evaluation May Lead to Nonconservative Analysis	04/09/93	All holders of OLs or CPs for nuclear power reactors.
93-27	Level Instrumentation Inaccuracies Observed during Normal Plant Depressurization	04/08/93	All holders of OLs or CPs for nuclear power reactors.
93-26	Grease Solidification Causes Molded Case Circuit Breaker Failure to Close	04/07/93	All holders of OLs or CPs for nuclear power reactors.
93-25	Electrical Penetration Assembly Degradation	04/01/93	All holders of OLs or CPs for nuclear power reactors.
93-24	Distribution of Revision 7 of NUREG-1021, "Operator Licensing Examiner Standards"	03/31/93	All holders of operator and senior operator licenses at nuclear power reactors.

OL = Operating License
CP = Construction Permit

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Original signed by
Brian K. Grimes

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per second, and uncertainties in numerous amplifiers and the multiplexer. Thus, an actual flux signal could exceed the flux-doubling setpoint used to analyze the boron dilution event. This condition could result in a loss of shutdown margin before the BDMS terminates an inadvertent boron dilution event. This problem may be generic not only for plants that rely on an automatic system such as the BDMS, but also for those that rely on a flux-doubling signal to generate an alarm for operator intervention. Alternatively, setting the setpoint too conservatively could unnecessarily allow the BDMS to be activated and the RCS to be borated. This sequence of events would have detrimental effects on operations.

On March 23, 1992, the staff met at NRC Headquarters with the licensee and Westinghouse to discuss issues about the BDMS. The licensee informed the staff that it had investigated various alternatives and found none readily available to restore the operability of the BDMS but would continue to evaluate this problem with Westinghouse. Later, on December 15, 1992, the staff met with Westinghouse and licensees of Westinghouse-designed plants which use the BDMS. It was concluded that the BDMS was unreliable because of the large uncertainties associated with the indication of a true flux doubling by the nuclear instruments. Therefore, this problem may be common to all PWRs that rely on a flux-doubling signal to mitigate a boron dilution event before criticality can occur.

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NOTE: THE PM OF COMANCHE PEAK (TOM BERGMAN) HAS REVIEWED THIS DRAFT INFO NOTICE.

Pet. Wen 3/3/93

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